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ON THE SPHEROIDAL CONDITION OF LIQUIDS.

BY CHARLES TOMLINSON, F.R.S.

I HAVE read, with considerable interest, Professor Barrett's note on this subject (Vol. I., p. 159).

On several occasions, during a long scientific life, I have engaged in researches thereon; and it may be interesting to recapitulate the various phenomena, leaving the task of deciding which of them fall under the new theory, and which belong to the old, to the competent judgment of Mr. Stoney and Professor Barrett.

So long ago as the year 1838, my "Students' Manual of Natural Philosophy" contained an account of my first researches. I quote, with some abridgment, from pp. 553 *et seq.* of that work.

After describing an experiment by Professor Baden Powell on the so-called repulsion of heat, in which Newton's rings disappear on applying the flame of a spirit-lamp to the lower lens, the text proceeds thus:—"There is another striking phenomenon, discovered by Leidenfrost in 1756, which seems to prove the existence of a repulsive force between heated bodies, which force augments with their temperature. If a polished metal vessel, such as a platinum crucible, be raised to a red or white heat, and several drops of water be allowed to fall into it, they unite into a globule, which spins rapidly round without ebullition, and evaporation is slow in proportion as the temperature of the vessel is high. It is necessary to the success of this experiment that the globule, whether from calorific repulsion, or any other cause, be not in contact with the heated metal; and accordingly we find that if the vessel be removed from the source of heat, and allowed to cool down to a certain point, the water flashes into steam by coming into contact with the heated metal. I find that these phenomena apply also to ether, alcohol, and many saline solutions, but not to fixed oils. I have also varied the experiment by employing a fixed oil at 450° or 500° Fahr., instead of the heated metal. When oil of turpentine is dropped upon its surface, it forms a disc, with a perfectly well-defined edge; the disc rotates rapidly in a horizontal plane, and soon disappears by evaporation. If several drops of ether be placed upon the heated oil, they unite and form one large globule, which rotates rapidly, and moves swiftly over the surface. If now a drop of water be placed upon the heated oil, or rather be gently delivered to it from the end of a pipette, it forms a similar figure to the ether, and behaves like it; but soon the two globules coalesce, and the compound drop moves and rotates as before; or it may sink below the surface of the oil, burst into vapour, and scatter the oil; hence caution is required in conducting this experiment. In some cases, however, the globule may be thrown up again to the surface, and continue to rotate as before.

"It is remarkable that a drop of so volatile a liquid as ether should rest upon the hot oil without evaporating much more quickly than a similar drop would do on a surface at the ordinary temperature of the air; also that water, which is so much denser than the hot oil, should rest upon it, and move about with great rapidity. By colouring the water with ink it will be seen that the ether completely envelopes the aqueous globule, and even increases its duration. Alcohol, wood spirit, naphtha, and bi-sulphide of carbon form globules on the surface of the hot oil, and behave in the same manner as the ether. Ether also forms a rotating globule on the surface of hot water and mercury. If sulphuric acid be heated to about 400°, and ether be placed on its surface, it forms globules which dart about with great rapidity. Alcohol also forms globules, but naphtha and turpentine form discs, which soon disappear with decomposition."

In 1845, I was introduced to M. Boutigny, in the laboratory of King's College, London, where in the presence of Professor Miller, and some other scientific friends, he showed the experiments which he had shortly before described in a small pamphlet. He also described his results in a lecture at the Royal Institution, which I attended.

M. Ganot attributes to Boutigny the invention of the term, "spheroidal state of liquids," but the term is much older than his researches. In conversing with him, he freely admitted that I had anticipated him in many of his results. He stated that water in the hot crucible evaporates fifty times more slowly than if boiling, and that the higher the boiling point of the liquid, the hotter must be the metal; that any liquid in the spheroidal state is always below the temperature of its boiling point. Water, for example, is at 95.5°C.; alcohol at 75.5°; ether at 34°; sulphurous acid at —10.5°; but that the vapour disengaged is higher in temperature. The lowest temperature of platinum necessary to the production of the spheroidal state is for water 171° C., for alcohol 134°, and for ether 61°. If boiling water be put into the heated crucible, its temperature immediately falls 4° or 5°. Anhydrous sulphurous acid boils at —10° C., and in the red-hot crucible some degrees below that point, so that when water is added it instantly congeals, and we have the singular spectacle of a lump of ice being formed in, and turned out of, a red-hot crucible. I was so fortunate as to be present when Faraday first exhibited the still more singular spectacle of freezing mercury in a bath of solid carbonic acid in ether, contained in a red-hot crucible.

Boutigny also showed that a liquid in the spheroidal state is not in contact with the hot metal. For this purpose a silver plate was made horizontal, and heated. Water blackened with ink was dropped upon it, and, on directing the eye through the space between the globule and the heated surface, the flame of a candle could be seen on the other side. Poggendorff established the same fact more

elegantly, perhaps, by showing that the globule would not pass an electric current.

It was also shown that solids, in liquefying in a hot metallic capsule, pass into the spheroidal state, as in the case of iodine. So also liquids become spheroidal if dropped upon a hot plate contained in an exhausted receiver.

It had long been known in the iron forge that a highly-heated bar of iron or of steel, plunged suddenly into water, will continue so for some short time, without perceptibly affecting or being affected by the water. Boutigny shewed an effect of this kind by raising to a red heat a solid cylinder of silver, and lowering it into a beaker of water; although it must be admitted that when I saw him attempt this experiment a second time, the beaker suddenly exploded. A copper vessel was heated by means of a spirit-lamp, water was dropped into it, and the neck tightly corked. On withdrawing the heat, the water came into contact with the hot metal, flashed into steam, and drove out the cork with explosive violence. Boutigny imagines that some steam-boiler explosions may thus be produced. If, for example, during dinner-hour the water shall have entirely evaporated, the bottom of the boiler may become red hot, so that on readmitting water it may pass into the spheroidal state, and coming in contact with the heated metal may flash into steam, beyond the capacity of the valve to remove it before an explosion takes place.

Another wonderful illustration of the spheroidal state was introduced by Boutigny, and repeated by Professor Williamson at one of the meetings of the British Association, viz., passing the moist hand to and fro through a stream of molten iron from a cupola furnace. It has been supposed that some of the persons subjected to the fiery ordeal of the Middle Ages may have owed their safety to some such principle. At the Polytechnic Institution, some years ago, a boy with naked feet stepped rapidly over pieces of iron hot enough to explode gunpowder. I was informed at the time that his feet had been wetted with a solution of sal-ammoniac. There is also a well-known conjuring trick, in which a man licks a bar of red-hot iron, the moisture of the tongue preventing any ill-effects. Here, too, we may refer to an old observation by Macquer, that gold spins when melted into a globule, and that minute fragments of grit on its surface are powerfully repelled. When the metal is fused by the action of a large lens, fine powder on the surface is dispersed, as if by a powerful blast of the breath.

Boutigny adopts the theory of a repulsive force between the hot surface and the liquid, or that the tension of the vapour keeps the globule at a distance, so that the liquid is not heated by contact, but only by radiation, water being diathermanous, the rays of heat pass through without raising its temperature. It may also be added that the vapour is a bad conductor of heat, and that evaporation from the surface of the globule carries off the heat as it arrives.

Mr. Perkins, the engineer, also showed that water can be dropped upon a red-hot metal colander without passing through; and even that water will not pass through a red-hot metal pipe.

In connection with the spheroidal state, Eisenlohr remarks that if boiling water be covered with lycopodium, the finger can be passed into it with impunity; but this, I imagine, arises from the fact that the powder prevents the finger from being wetted.

With respect to the spheroidal state of liquids at common temperatures, I have had abundant opportunities of observing it in the course of my researches on the Cohesion Figures of Liquids. I may briefly refer to some results obtained by me in 1863. Essential oils were used, and it was found that the duration of the spheroidal state formed an approximative method of determining their purity. Three glass vessels were used, each about $2\frac{1}{2}$ in. in diameter; they were nearly filled with water, on which a film was formed from turpentine procured from a colour-shop. The mean of twenty-four experiments gave $15\frac{1}{6}$ seconds for each drop, placed on the film, and assuming the spheroidal state. The turpentine was next distilled off caustic potash, and a similar series of observations made with the fresh distillate, when the mean duration of the globule in the spheroidal state was now $36\frac{1}{4}$ seconds, or about 7 to 3.

The spheroid, whether rolling about or stationary, displays active motion among its particles. If a little lycopodium powder be shaken over the globule, and this rude treatment do not cause it to break up, the powder will display the convective currents of the globule, streaming rapidly down its outer surface, and ascending by the central vertical axis, to separate again at the top, and stream over the surface again to the bottom.

An essential oil does not readily assume the spheroidal state on the film of another oil, and a drop of a fatty oil does not readily become spheroidal on a film of a fatty oil; but by raising the temperature of the surface, globules of various liquids can be readily formed, as already noticed.

In Professor Tyndall's work on "Sound" (1867), he describes (p. 154) a method of producing some of Chladni's figures by drawing a fiddle-bow over the edge of a glass goblet containing ether or alcohol; and he gives to M. Melde the credit of "this beautiful experiment." The experiment is really due to me, and was described with a figure in Thomson's "Records of General Science," vol. iv., p. 14, published in July, 1836. It was also shown that fixed oils do not show the usual beautiful crispating figures under the influence of the fiddle-bow, but do so readily when heated.

In the appendix to my "Cyclopædia," published in 1866, a number of spheroidal figures are given in the form of a four, six, or eight-rayed star formed by pouring turpentine on water at about 150° F. in a goblet, so as to form a thin layer, and drawing the fiddle-bow against the edge. The curved spaces outside the circle represent portions of liquid often beautifully reticulated, that ascend the glass in a vertical direction while the crispating fans are on the surface of the liquid, and the spheroidal stars in the centre, their rays pointing to nodal lines.

A brass cannon, 6 ft. long, has been found by an agriculturist, whilst ploughing, at Coorum, near Soopa, in the Bhimthudy talooka. This cannon, it is said, was manufactured by Michael Burgerhays, and is dated 1640.

The Society of German Railway Administration has resolved upon opening every three years prize competitions of a total amount of 30,000 marks, for important inventions in railway matters, namely:—(1) For inventions and improvements in the construction of railroads—1st prize, 7,500 marks; 2nd prize, 3,000 marks; 3rd prize, 1,500 marks. (2) For ditto in the means of transportation, and their use—prizes the same as at 1. (3) For ditto respecting the general administration of railroads, railroad statistics, and prominent subjects of railroad literature—1st prize, 3,000 marks; 2nd and 3rd prizes, 1,500 marks each. The award of a prize is not to prevent the inventor from patenting his invention or his sale of the patent. The first competition of this kind has been made public, and applications are to be sent in between Jan. 1 and July 15, 1884, to the managing director of the society at Berlin.

A GEOLOGICAL EXCURSION.

By GRANT ALLEN.

ONE day last week, having nothing in particular to do (a rare complaint with public writers), and having exhausted all the available walks in our own immediate neighbourhood, in space and time, it struck me that it would not be a bad idea to jump backward over a few hundred million years or so at a bound, and take a short holiday excursion in palæozoic Britain. This idea was largely suggested to me by the fact that Dr. Hull, of the Geological Survey of Ireland, has lately published a series of charts which enable intending tourists to make their own way through that distant region with comparatively little expense or trouble. So, with a friend to accompany me, and a good map in my hand, I set out boldly on my travels across the ages in a small steam-yacht, whose whistle and screw were certainly calculated both to surprise and alarm the unsophisticated inhabitants of the primæval seas through which we sailed.

Having our choice of all terrestrial time before us, we decided to make our trip in that epoch which Dr. Hull describes as Devono-Silurian, the one, namely, when the massive Old Red Sandstone deposits of Scotland were first laid down. For this purpose, we started our yacht from a port in the North of France, where we found a considerable mainland stretching east and west, into Germany, on the one hand, and over what is now the open Atlantic on the other. Due north of us, however, a wide sea occupied the central bed of the English Channel, bounded to the south by the continental land on which we then stood. We steered our course straight for the Isle of Wight; but when we had reached the spot where Ryde usually stands, I was surprised to find nothing but a blue sea still stretching in front of us over the whole area of southern England. I observed to my friend that this was very curious, as I didn't remember that there were any strata of corresponding age in that part of modern England, as one would naturally expect if it had once been occupied by a Devonian sea; the only deposits of the sort that I knew were in North Devon, lying just around the Foreland point. My friend, however, at once reminded me that such strata really extended over all the south coast from Cornwall to Kent, only they were concealed by overlying deposits of later age, and could not be recognised except by means of deep borings. "There could be no doubt," he said, "that these buried sediments were laid down by the very sea over which we were then sailing; and from the nature of the sediments, and the manner in which they were deposited, he had no hesitation in concluding they had been derived in part from land lying over in the direction where Norfolk and Lincolnshire are now to be found. By turning our bows towards that quarter, therefore, he hoped before long to arrive at a contemporary land-surface of considerable extent.

In pursuance of these views, we sailed on over the whole valley of the Thames, with open sea stretching away to the west of us, as far onward as Wales and Ireland. We noted in passing that the sea contained a few strangely-armoured fish, and a good many cephalopod mollusks; but we, of course, observed that none of the aquatic mammals were yet developed, and that the fauna generally seemed of a decidedly low and unspecialised type. On reaching Warwickshire and Northamptonshire, however, we saw a low shore lying dimly in front of us; and my friend pointed out to me that this long peninsula, stretching westward from a continent which apparently occupied the modern bed of the German Ocean, was part of the land surface from which the sediment of southern England was derived; while in all this part of England, which appeared to us as land, there are, of course, now no strata of this age, as rocks represent the beds laid down under water, but land-surfaces are answered by a blank on the contemporary geological map. "By making westward," my friend said, confidently, "we shall round the peninsula, and strike through a wide strait up to the Cumberland mountains. Don't you remember that strata of about this age, or a little earlier, run up the whole eastern half of North Wales? I'm pretty sure the sea in that direction hasn't yet been closed up, and if we run for the Severn valley we shall doubtless find a practicable road." As it turned out, he was quite right; for though we saw high hills on the left already marking the spot where the Snowdon region now stands, we found a clear passage through Cheshire and Lancashire, as far north as the Lake District. There, a mountainous shore stood in front of us, and we found it absolutely necessary to disembark. "The mountains of modern Britain are already beginning to outline themselves," said my friend. "Though they may perhaps be submerged again more than once in secondary and tertiary times, I can plainly see that they will always maintain their relative elevation, and will form at one time islands in the sea; at another time, submarine ridges; at a third time, mountain chains; but they will never cease to be comparatively high ground, surrounded on either side by lower patches.

We left our steam-yacht in a little harbour not far from where Durham now stands, and struck our way across the land, still northwards, through a dense forest of curious-looking trees. Most of them were huge club-mosses and waving tree-ferns, interspersed with some wholly extinct types of very tropical and curious aspect. They resembled a forest of horse-tails more than anything else that I had ever before seen. We saw a few conifers, but were not quite certain whether there were any true flowering plants of the higher orders in the place, for though we fancied we noticed one here and there, we could not pick any good specimens to make quite certain, as the light in the woodland was dim and very confusing. There were some odd-looking insects, however, all of them very rudimentary, and combining traits now only found in quite distinct orders. After traversing this region for about forty miles, we came on the second day to the shores of a large lake. My friend was much delighted when it burst upon us from the summit of a little knoll, covered with scaly Lepidodendroids, and stiff, formal calamites. "This," he said, "is clearly the Lake Cheviot of Professor Geikie. From it have been derived the old red deposits of modern Northumberland and Berwickshire. It was once (in upper Silurian days) an arm of the sea, and stretched as far as the Solway Firth; but I believe we shall now find that end of it dried up, and we shall be able to round it easily at its western edge among the Cheviots. How far it stretches eastward over the bed of the German Ocean, I'm sure I can't say, for we know very little of the submarine deposits in that direction." So, acting on his advice, we turned westward, and successfully got round the corner of the lake before we had fairly reached the middle of modern Northumberland.

The southern hill region of Scotland we found chiefly covered by a broad plain, with the same vegetation as that of the country we had already traversed; and, after three days' good walking through a more than tropical jungle, we arrived at last at the shore of a second and much larger lake. "This," my companion exclaimed, "is clearly Geikie's Lake Caledonia. It is the largest one of all these great inland seas, but I hope its water is fresh, or, at least, scarcely brackish. It will be useless for us to think

of turning its edge; for I know by the extent of the modern strata that it spreads right across the face of Scotland, and probably far out into what is now the sea on either side. Indeed, as similar deposits are found in Ireland, as far as the Fintone beds, I am inclined to suspect that Lake Caledonia stretches in that direction almost as far as the Atlantic coast of Ulster. Our only plan is, therefore. to build a raft and sail right across it; for this is certainly the great sheet from which the lacustrine sedimentary strata of the Scotch lowland belt between Edinburgh and Glasgow were originally derived."

Following his advice, we built ourselves a large raft, and shaped our course north-westward across this primæval Superior. After sailing from about the point where Edinburgh usually stands to the centre of Perthshire, we saw in front of us a long range of mountains, which we recognised at once as the precursors, or first rough drafts, of the Grampians. These, my friend told me, must represent the dividing ridge between the two main lacustrine beds of Old Red Sandstone in the Scotch Highlands, and by crossing them, we should probably come upon the largest of all the contemporary inland waters, the Lake Orcadie of Professor Geikie. We therefore pushed our way through the dense jungle in a northerly direction, and from one of the highest summits in the range, we caught a glimpse on the left of another considerable inland sheet, which we felt sure was Geikie's Lake Lorne, occupying the basin now marked by the terraced volcanic hills of North-Western Argyllshire. Descending from the ridge, we soon found ourselves on the wide shores of Lake Orcadie itself, an immense stretch of open water, indented into numerous bays, and bounded on the near side by a range of high hills on the site of Ross and Sutherland. How far it spread away to the north-east, over the modern bed of the German Ocean, towards Norway, we could not quite make out; but we knew it was fully big enough to have left its sediment along the whole shores of the Moray Frith, across the corner of Caithness, and onward as far at least as the Orkneys and the southern outliers of the Shetland group. We felt it would be quite impossible for any raft to live in such an inland sea as that, and so we halted here as the final end of our excursion, being deterred from proceeding further partly by fear of danger, and partly by our ignorance of the deposits underlying the Atlantic and the German Ocean, which prevented us from obtaining a trustworthy chart of the regions now covered by their beds.

The Snow Plough in India.—The snow plough has been used on an Indian railway this winter for the first time. At Darjeeling, on January 26, so heavy a fall of snow took place, that the train could not proceed until a plough had been fixed to the engine. At Naini Tal, from January 24 to January 28, the snow and rain rendered the station almost inaccessible, and caused great difficulty in forwarding the mails.—*Engineering.*

A Non-inflammable Insulating Material.—Messrs. W. A. & S. E. Phillips have taken out a patent for an improved method of making the insulating bodies of electric light conducting wires non-inflammable. The invention consists in passing the wires, covered or uncovered, through a solution of tungstate of soda. According to another part of the invention a concentrated aqueous solution of tungstate of soda is prepared and poured into boiled linseed oil, which is heated and kept stirred until the water has evaporated. A portion of this fluid is then mixed with the insulating compound used to cover the wire.

"OUR BODIES:"

SHORT PAPERS ON PHYSIOLOGY.

By Dr. Andrew Wilson, F.R.S.E., &c.

No. XI.—THE CIRCULATION OF THE BLOOD.

THAT blood circulates perpetually through our bodies, is, of course, one of the acknowledged truisms of our physical life. So tacitly, however, is the fact taken for granted, that very few persons seem to trouble themselves further regarding the mechanism which keeps this perpetual flow in motion. Possibly the most salient features of the blood-circulation consist in the knowledge that the *heart*, by its incessant movement, is charged with the duty of sending blood through the body; and that the blood, secondly, flows, or is thus driven, through certain pipes or *bloodvessels*. The heart in this light is a kind of force-pump; and if we add that it is a muscular force-pump, we shall have found a rough and ready, but essentially correct, idea of the nature of the heart. As a *hollow muscle*, the heart no longer appears as a mysterious organ. It is hollow, to allow blood to pass through it; it is a *muscle* (or rather collection of muscles), that it may *propel* the blood through the body by its forcible contractions. For, after all, the same force by means of which we write a letter, or move our legs in walking, is that which drives blood through our bodies. The muscles of our fingers and arm *contract* when we write; the heart's muscular substance, in the same way, *contracts* when the heart "beats." The description of a heart as a "hollow muscle" is one also which applies with equal force to all hearts; and the heart of an insect or the pulsatile organ of a snail or oyster as fully conforms to this definition as that of a man.

We have already seen that the blood in the course of its circulation exists under a double phase. It goes forth from one side (*the left*) of the heart and from the lungs to nourish the body. It is then pure blood; it travels through pipes or tubes called *arteries*, and hence it is often spoken of as *arterial* blood. If we trace any arterial bloodvessel through its ramifications, we may see that it divides and subdivides, and finally spreads out into a network of fine, delicate-walled vessels, known as the *capillaries*. So minute are these capillaries that, as a rule, they will allow only a single row of red blood corpuscles to pass along their interior at one time, like soldiers in single file. The diameter of these capillaries is, therefore, about the one three-thousandth of an inch. We can readily see that as the tissues of our frames are permeated by such a dense network of bloodvessels, they must receive not only a very large and constant supply of blood, but must have that fluid likewise brought into connection with the most minute parts or "cells." The fluid part of the blood strains through the capillary walls, and thus bathes the tissues in nutriment; and it is this fluid part of the blood which, in turn, is taken up by the *absorbent* vessels, as described in a former paper.

We may further observe that at no part of the circulation do the bloodvessels end abruptly, or like a street without openings. On the contrary, the special feature of the circulation is, that it is carried on in a set of closed tubes, which are everywhere continuous. If blood escapes from any bloodvessel at all, it must do so either naturally, that is, by straining through its walls, as already described; or it must escape through injury to the vessel. A wound of any bloodvessel, small or large, is thus really an opening into a system of close and continuous pipes.

The blood, then, which the *arteries* have carried to

nourish the body, passes into the *capillaries*. The nutritive functions of any part of the blood-flow has been discharged when the tissues have received their quantum of blood through the capillary walls. If we trace the blood-flow onwards—as we may do when the web of the frog's foot is microscopically viewed—we see that the capillaries gradually tend to become of larger diameter; and finally, by their union, we discover that the capillaries form *veins*. The name "vein" is familiar enough in common parlance. We know also, as a matter of everyday knowledge, that the name "vein" is given to the bluish-looking vessels we see in the back of the hand, and still more plainly in the arm itself. For the veins, as a rule, lie near the surface, whilst the arteries are deep-seated.

If we grasp an object firmly in the hand, and tie a bandage say, in the middle of the arm, we notice that the veins grow larger and more prominent. Why is this? The reply is evident. We have by our bandage obstructed a flow of blood which is passing *up the arm towards the heart and lungs*. Hence the veins swell on the side of the bandage furthest from the heart. We cannot show experimentally in such a simple manner the fact that in the arteries the flow takes place in the opposite direction, namely, *from the heart and lungs to the body*. But, if we were to place a ligature round any artery—such as the radial artery, in which the "pulse" is felt, at the thumb side of the arm, about a couple of inches above the wrist—we should find the vessel to swell *above* the ligature, instead of below, as in the case of the vein. In other words, we should then be interrupting a flow of blood, which is passing down the arm, to nourish the hand.

We learn from these plain facts, that the *circulation* of the blood really merits that name. It is an incessant round, from the heart and lungs as pure blood, through the body, and back to the heart and lungs as impure or *venous* blood. The impurities, or waste matters, which it has received from the body in its course, are got rid of by lungs, skin, and kidneys, and this latter work constitutes that known as "excretion." The course of the circulation—fully wrought out by the immortal Harvey—is as follows. The heart is two-sided (right and left); and each side consists of two compartments—an *auricle* and a *ventricle*. The *right* side of the heart deals with *venous or impure blood* alone; whilst the left side is concerned only with *arterial or pure* blood. The impure blood is returned by the veins to the right auricle; thence it passes to the right ventricle, which pumps it into the lungs. This is one-half, so to speak, of the circulation. In the lungs the blood is purified. Then it is passed on to the left auricle of the heart; and thence to the left ventricle, which propels it through the arteries all over the body. No mixture of pure and impure blood, therefore, takes place in the heart; but in frogs and reptiles such a mixture actually takes place, because in these animals the heart is not completely two-sided, or double, as it is in birds, quadrupeds, and ourselves.

AT Buda-Pesth, the capital of Hungary, the National Theatre is to be lighted by 1,000 Swan lamps.

IN connection with the photo-chemical action of ferric oxalate, Mr. Victor Jodin has observed that when 162·5 parts—one equivalent—of perchloride of iron, and sixty-three parts of crystallised oxalic acid, dissolved in a litre of water, are exposed in the sunlight, carbonic acid gas is set free in such quantity as to supply the requirements of plants enclosed in a vessel with it, the absorption and decomposition of carbonic acid by the plant being likewise a photo-chemical action, because it requires sunlight to aid it.

HOW TO USE OUR EYES.—V.

BY JOHN BROWNING, F.R.A.S.

(*Continued from p.* 194.)

TO the precautions we should take with regard to our own eyes, I must add a few words of warning respecting those of our children.

Never allow infants to be exposed to the full glare of the sun. Men shade their eyes with the brims of their hats and ladies carry parasols. But infants wear nothing which projects over the forehead, and they are constantly to be seen in perambulators with their unprotected faces turned full towards the sun, and I have frequently seen them left by careless people in such a position, with their poor little eyes closed, moving uneasily about, and unable to find any relief from their suffering.

It is difficult to estimate the amount of mischief which may be done to their eyes by such thoughtless cruelty.

The generally-received idea is that the spectacles worn should always be the lowest power the wearer can see clearly with, because the eye should have a slight adjustment left to make for itself. This is entirely wrong. The spectacles worn should fully meet the want of adjustment or focussing power.

There should be not only no conscious strain, but no unconscious strain, on the part of the wearer.

Sometimes, though not very often, persons imagine that because they have reached a certain age they *must* require spectacles. I recollect one instance of this kind. A well-known admiral came to me and told me that he had never worn spectacles, but he was quite sure he required them.

I gave him a book of test-types, and asked him to tell me the smallest size type he could read, and at what distance from the eye he could read it. Having obtained this information, I gave him a pair of very low power spectacles, suitable for a long-sighted person, and then, directly afterwards, a pair suited for a short-sighted person. He said he could see equally well with either. This was just what I expected.

"Now," said I, "here is a pair of spectacles that will suit you." He put them on, and, taking up the book, he said: "Oh, yes, I can see better with these than either of the others." "I thought you would," was my reply, "because if you take them off you will find that they are a pair of spectacle frames—there are no glasses in them!"

Had this gentleman gone to a quack, he would certainly have given him spectacles several years before he required them.

I only wish to say one sentence more on this subject:

Do not believe that any loudly puffed spectacles can be of special service to you. There is skill, of course, required in making good lenses of fine optical glass or Brazilian pebbles, but there is still more skill required in suiting the spectacles to each particular person's requirements.

How can this skill, only to be acquired by knowledge, combined with practice, be possessed by every watchmaker, chemist, jeweller, or ironmonger, who buys a dozen pairs of spectacles and writes up that he is a practical optician?

Remember that a pair of spectacles which would exactly suit one person would, in a short time, almost blind another!

I doubt if more than one person out of each dozen receives the full benefit from spectacles they should do, while there are four out of each dozen injure their eyesight by using spectacles unsuited to them.

Year after year I have been pained by people living in the country coming to me for spectacles, when their eyesight had been first injured by using improper lenses.

After long consideration I have been able to devise small instruments, which I can send through the post, and from the indications these give I can tell with accuracy what lenses are required. I have suited many cases in this way by correspondence, when the eyes of the correspondents differed greatly in focus.

Lenses of pebble, rock crystal, or, as it is termed by mineralogists, quartz, keep a clear, bright polished surface very much better than glass, and most persons prefer them. A correspondent of Knowledge inquired recently if these lenses were not cut at varying angles out of the quartz crystals, and whether this would not cause them to perform badly. My experience is that this is a matter of but little consequence where the image formed by the lens is viewed without magnification.

Still, first-class opticians should keep pebble lenses cut at right angles to the axis of the crystal, though they are necessarily more expensive.

Such lenses, when tested by polarised light, should give concentric coloured rings. Lenses not cut at right angles to the axis of the crystal give coloured bands.

You are doubtless aware that a glass eye is frequently worn by a person who has lost an eye either by an accident or by disease. But few people are aware how skilfully these glass eyes are made and fixed. They are kept in their place simply by atmospheric pressure, and can be removed and replaced without pain. They move in unison with the sound eye, and it is at times almost impossible to tell the difference between the artificial eye and the real one.

A celebrated surgeon states that he knew a case where a lady who had a glass-eye got married, and although she had been married two years, the husband had not discovered that one of her eyes was artificial.

I do not think a lady would be deceived in a similar manner. Ladies generally know "How to use their eyes," and I think a lady would find out if a gentleman had a glass-eye before he had been courting her a week.

And now let me say, in conclusion, that there are many points with regard to my subject at which I have scarcely glanced, and several to which I have only briefly referred.

My papers have been on what to see and how to see it.

I am well aware that I have treated most imperfectly these important subjects. I could not possibly have done justice to them in the space at my disposal. A long course of papers might be devoted to them, each more interesting, because more complete, than those I have written.

The charms of a forest in autumn, the changing hues of the clouds at sunset, the exquisitely modulated tints of a rainbow, the glory of the heavens on a clear night, filled with the innumerable suns which we call stars, all depend on light and colour for their beauty, and each of these would furnish themes for papers on which I should scarcely dare to try my hand, knowing as I do how much better they could be treated by the Editor of this journal.

Electric Lighting at Kimberley, South Africa.—A correspondent, writing to the *Electrician*, says:—"This installation consists of 32 Brush arc lamps, supplied by two 16-light machines driven from a countershaft by a Robey engine of 20 nominal horse-power. One circuit, three and a half miles in length, extends round the Kimberley mine, the other circuit, four miles in length, to De Beer's mine, down Du Toit's Pan and Victoria Roads. The wires are carried partly on the roofs of the houses, partly on iron poles, and the light is at present giving great satisfaction.

A DREAM OF INFINITY.

By De Quincey, after Richter.

[So many have asked to refer them to some work containing the quotation with which I closed my first and sixth lectures at St. James's Hall, that I have thought it might be well to give the passage in these pages, as I am in the habit of quoting it. I fancy it differs somewhat from the original, to which I have not referred now for many years. I used to depart purposely from the original, in places, for convenience of recitation; and it seems to me likely that, writing now in Belfast,* away from my books, I may not be able to quote the passage quite correctly. It runs, in De Quincey, very nearly as follows:—]

GOD called up, from dreams, a man into the vestibule of Heaven, saying, Come thou hither, and see the glories of my kingdom. And to the angels that stood around his throne, God said, Take him; strip from him his robes of flesh; cleanse his vision, and put a new breath into his nostrils: only, touch not with any change his human heart, the heart that weeps and trembles. It was done; and with a mighty angel for his guide, the man stood ready for his infinite voyage; and from the terraces of heaven, without sound of farewell, they passed into infinite space.

Sometimes, with the solemn sweep of angel wings, they passed through Zaharas of darkness, through wildernesses of death, that divided the worlds of life. Sometimes they passed over thresholds quickening under prophetic motions from God. Then, from beyond depths counted only in heaven, light dawned as from a sleeply film. By unutterable pace, they passed to the light, the light by unutterable pace to them. In a moment, the rush of planets was around them; in a moment, the blaze of suns was upon them.

Then came eternities of twilight, that revealed, but were not revealed. On the right hand and on the left towered gigantic constellations, that by self-repetitions, by answers from afar, by counterpositions, built up triumphal gateways, whose archways and architraves, horizontal, upright, rested, rose, at altitude, by spans—that seemed ghostly from infinitude. Without number were the archways, beyond memory the gateways, past counting the architraves. Within were stairs that scaled the extremities around. Above was below, below was above, to the man stripped of gravitating body. Depth was swallowed up by height insurmountable, height was swallowed up by depth unfathomable.

On a sudden—as thus they rode from infinite to infinite; on a sudden—as thus they tilted over abysmal worlds; a mighty cry arose that systems more mysterious, worlds more billowy, other heights, other depths, were coming, were nearing, were at hand!

Then the man sighed and paused, shuddered and wept; his overladen heart uttered itself in tears; and he said:—"Angel, I will go no farther; for the spirit of man acheth with this infinitude. Insufferable is the glory of God! Let me lie down and hide me in the grave from the persecution of the infinite; for end I see there is none." And from all the listening stars that shone around there issued a choral voice, "Angel, thou knowest that the man speaks truly; end is there none that ever yet we heard of." "Is there no end?" the Angel solemnly demanded: "Is there indeed no end? and is this the sorrow that kills you?"

But no voice answered, that he might answer himself.

Then the Angel threw up his glorious hands to the heaven of heavens, saying:—

"End is there none to the Universe of God; lo, also there is no beginning."

* This may serve to explain the occurrence of certain misprints in last number of Knowledge, especially in letter 798, which I had no opportunity of correcting.

DEATH OF WORLDS.

By Richard A. Proctor.

I AM often asked, when I have shown how (so far as science can judge) all the orbs in space seem to tend towards death, whether there may not be some way in which this seeming tendency may be counterbalanced by some restorative forces. When one has to reply that science does not at present recognise any such forces, that the theories devised by Mattieu Williams, Siemens, and others to that end are not only not supported by scientific evidence, but directly opposed to it, the idea seems commonly entertained that science rejects the belief in any restriction of the energies which seem passing continually away from suns and planets. Yet, in reality, such a reply means nothing of the sort. On the contrary, it is as certain that science has shown nothing *against* the existence of any restorative forces, as it is that science has as yet shown nothing in favour of such a process. Science simply knows nothing either on one side or the other. And I think if men rightly understood the limitations of scientific research, they would see no reason to wonder that science should be thus unable to reply to a question so exceedingly difficult. Our knowledge has grown more and more, and is ever growing more and more, till it seems as though it would eventually extend over all time and all space; yet it is in reality, and ever must be, extremely limited compared with what actually is. In regard to the question of the seeming wasting away, slowly, yet surely, of the life of every sun and every planet, we are much in the position of creatures whose whole lives, lasting but a few days perhaps, should be passed beside a running river. They would learn, if they had the power of reasoning, that the waters of the river were passing continually away in one direction, and they would be apt to infer that unless the store of water were infinite, the supply must at length be exhausted. If we imagine them combining together information derived from others of their kind, up stream and down stream within limited distances, and also storing up, for what would seem to them a long period of time, the information gathered by generation after generation, they would learn that the river was broader lower down and narrower higher up, and that it had remained (on the whole) without appreciable change. They might even, we may imagine, learn how the river was fed by smaller streams, how it flowed into a larger river, that into yet larger rivers, and so (possibly they might learn or guess) into a sea of extent, to their minds, practically infinite. Still their science could give no answer to the question how the river might not really waste away, as it seemed to be wasting (though inappreciably in long periods of their time). The actual process of restoration, which, to us, seems so simple a matter, could not possibly suggest itself to creatures having their limited knowledge and experience. That the air in which they lived contained the stores from which the river, unlike in all respects, was constantly nourished, would seem incredible if suggested to them; but as a matter of fact, the idea would be to them utterly inconceivable. It could not occur to their minds at all. By parity of reasoning, we may well believe that the way in which the energies of suns and planets are continually restored, if (as I believe myself must be the case) they are restored at all, is utterly outside the range of our knowledge and experience. Thus understood as suggesting the kind of way, not the way itself, in which such restoration may be effected, the following strictly unscientific ideas may be regarded as admissible. Men were long deceived in regard to space,—they thought this earth all important in space, whereas now they know it to be the merest point compared with the solar system, this system the merest point compared with the distances separating star from star, and the whole of the system of stars utterly lost in unfathomable depths of space. Men were deceived with regard to time,—they thought the duration of this earth represented all time; was, at least, central in time; they know it now to be the merest second compared with the duration of the solar system, the duration of this a mere moment compared with the uncounted æons, of whose progress the star-depths tell us, and even these as nothing compared with the eternities of past and future time amid which they are lost. May it not well be, then, that as men have deceived themselves with regard to both space and time, so also have they deceived themselves with regard to the very structure of the universe itself? May it not well be that the solid, liquid, and vaporous forms of matter with which alone we are acquainted are not the only forms of matter which exist? May there not be a higher order of universe, of which the suns and planets of the universe we know of are but as the atoms and molecules? May there not be a lower, or rather a rarer, order of universe, as much finer in texture, so to speak, as that imagined higher order is in a sense grosser? But we know that there is a rarer order of universe—the æther of space—which permeates our universe, flowing through the densest solids as the breeze passes through the forest trees. The waste energies of stars and planets are expended in the æther of space. May they not subserve within it important purposes, though we may not be able to conceive how? May they not continually revivify that universe, while in turn our universe is continually refreshed and restored by receiving supplies of energies passed on to us from a higher order of universe? And thus from higher and higher orders of universe, absolutely without end on one side, to lower and lower orders as absolutely without end on the other side, there may be constant interchange of energy, instead of the dying out of any one among these various orders of material universe.

All this, as I have said, is outside science. For science deals with what we know of, what we can observe, analyse, and investigate, while these interchanges of life and energy we can never analyse or test. But thus it is in whatever direction we investigate the universe. On all sides we reach the unknown, the unknowable. We approach in every case the threshold of infinity—infinite space and infinite time, infinite power and infinite variety. In dealing with infinity we are dealing with what is for us absolutely inconceivable, though its existence is absolutely certain.—*Newcastle Weekly Chronicle.*

The Approaching Solar Eclipse.—The U.S.A. Navy Department placed a vessel of war at the disposal of the National Academy of Sciences, to take a party to the South Pacific, for the observation of the solar eclipse which is to take place on May 6.

The average time occupied in the transmission of telegrams between Australia and England during 1881 is stated to have been three hours and fifteen minutes.

In a report of the British Iron Trade Association, giving the production in the United Kingdom of different descriptions of manufactured iron in 1882, the quantity of ship-plates is put down at 495,000 tons, or 30·53 per cent. of the total production; boiler and other plates, 64,000 tons, or 3·94 per cent. of the total production.

XUM

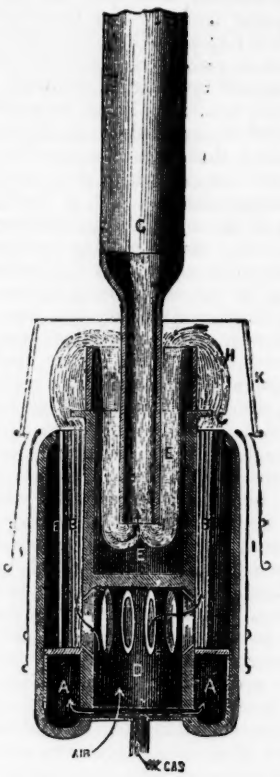
THE CRYSTAL PALACE ELECTRIC AND GAS EXHIBITION.

FINAL NOTICE.

THAT Messrs. J. Defries & Sons are no novices in the art of decorative fitting is amply demonstrated by the charming display made by them in conjunction with the Gülcher Electric Light Company. Anything more chaste in design, more delightfully soft and elegant in conception, is beyond our highest imaginative flights. Any effort aiming at more than the briefest description would necessarily be futile. Suffice it to say, therefore, that if anything were wanting to try, to the utmost, the capacity of the electric light for decorative and illuminating purposes, that want is ready to be supplied; and when we remember the advantages, from a sanitary point of view, pertaining to the adoption of the new illuminant, the prediction that it will, before long, make its way, at least, into the mansions of the wealthy, strikes us as a very safe one. We say the wealthy advisedly, for it is practically beyond dispute that the incandescent system is somewhat more expensive than gas-light, while the arc system is not applicable to domestic lighting. The difference in cost is, however, not so great as to prevent many consumers, even in business houses, adopting the electric light on account of its many advantages. The Gülcher-Crookes system is one of the most perfect at present in the market. It embraces a useful and economical dynamo, an arc lamp which equals the Fyfe-Main in steadiness, and a good incandescent lamp. The peculiar features about the system are that both forms of lamp are maintained in the same circuit, the arc lamps being fed in parallel circuit. We have for a long time wondered why efforts in this latter direction have not been more extensively made, and it is still somewhat surprising that this is the only system which attempts it. The electro-motive force or pressure of the current generated by the Gülcher Dynamo is only 60 volts (a volt being, roughly speaking, the electro-motive force of a single Daniell cell), no matter how many lamps are in circuit, while such a machine as the Brush, maintaining 40 arc lamps in a single circuit, has to provide a current of something like 2,000 volts, a current which, to say the least, is highly dangerous to those who have anything to do with it. So impressed are we with the advantages inherent in the Gülcher Company's system, that we shall doubtless find occasion to say more concerning it in an early number.

The Lever Arc lamp has been removed, and its place taken by the Werdemann Company, who have erected three of their Lea Arc lamps in the tropical section, five others being suspended over the centre transept. The latter are, however, naked lights, and are an intolerable nuisance to anyone sitting in the chairs opposite the orchestra, the irregular glare dazzling one's eyes terribly. Surely but little is expected to be gained by compelling people to see a light in this manner.

The Gas Section has not brought forth any novelties since our last notice, and the Bower-Griscom lamp remains the champion. The principle of the "Regenerative" lamps is deserving of some attention, the first form on this principle that was introduced being that of Messrs. Siemens. It is tolerably well known that the illumination produced by the burning of gas is due to the presence of minute particles of carbon. By raising the temperature of the flame, combustion is rendered more perfect, and the illumination, perforce, more brilliant. In the Regenerative Burner, this effect is produced by supplying heated instead of cold air to the flame. This is accomplished by utilising the heated products of combustion, as they pass away from the flame, to heat the gas as well as the air as it passes towards the flame. The burner is illustrated by the accompanying diagram. The gas in a cold state passes through the gas-chamber, A, and gas-tubes, B, to the point



of ignition, C. Cold air enters the air-chamber, D, and in passing to C, between the tubes B, it is heated, and then distributed to the flame by means of a circular collar. The flame burns around the porcelain cylinder, H, and turning over the top of it, descends into the interior of the burner or regenerative heating chamber, E—an effect resulting from a continuous current in the chimney, G. The temperature of the heating chamber is said to be 900° C., the consequence being that the gas and air in the surrounding chamber (during the process of their ascent from the bottom to the top of the burner) are raised to a similar temperature, thus increasing the illuminating power. Outside the burner is a jacket of thin metal, I, between which and the burner a current of cooler air ascends to prevent the overheating of the burner, and to add to the supply of air to the flame. K is simply a glass cylinder for protecting the flame. Looked at from below, the burner looks uncommonly massive, and not over pretty, but its efficiency is admitted to be very high. To the Londoner, it is not altogether a novelty, as it has been in use in certain parts of the City for some months. Some interesting figures are given by Colonel Haywood in his report to the Commissioners of Sewers on the Holborn experiment. The illuminating power of each lamp is stated by the company to be equal to 130 candles, but no photometric observations have been made by the Commission. The ordinary bats-wing burner produces a light of about 14 candle-power, so that the illuminating power claimed for the new lamps is

9·28 times that of the ordinary lamps. The cost of lighting the thoroughfare appears to be, by the ordinary system, £99. 7s. 4d. per annum for twenty-two lamps, and by the cost system, £379. 6s. 4d. per annum for a like number of lamps. The general result appears to be, therefore, that the lighting with the Siemens burner gives nine times the luminosity, at about three and three-quarter times the cost of the superseded lamps. None, however, but those blind to the beauties and uses of the electric light will be prepared to admit of the Siemens lamp that it "enables shades of colour to be accurately detected"—or that this is an advantage which (as is claimed in the pamphlet issued by the Siemens Company) "cannot be accomplished satisfactorily by any other artificial light." Nor is it altogether correct to designate gas-light as the "light of lights." There is no doubt that, however young and inexperienced the electric light industry may be, we should never have seen the recently-effected improvements in gas-lighting had it not been for the fear of a close and determined competition on the part of electricity.

Another very interesting exhibit is Clark's "Recuperative Shadowless Lamp," in which the flame is in the form of a ring, the whole of the light being projected downwards, instead of mainly upwards, as in the Siemens. Want of space, however, will not permit of anything more than a reference to this lamp.

The Exhibition will have closed by the time this appears, and many of the exhibitors will have packed up and cleared away. If there is any lesson to be drawn from the exhibition, it is that gaslight is not by any means a thing of the past, nor is it necessary that our halls and rooms should be rendered untenable by the products of combustion, as, in the majority of the lamps exhibited, these products are entirely carried away, and help, inductively, to ventilate the room. So far as electric lighting is concerned, it seems impossible to say much concerning its prospects till the Board of Trade have finished their share of the work in granting "orders." This much, however, may be said, the companies will be a long time before they recover from the blow they received last summer at the hands of stock-jobbers.

THE MOON IN A THREE-INCH TELESCOPE.

BY A FELLOW OF THE ROYAL ASTRONOMICAL SOCIETY.

IN commencing our examination of some of the typical and more remarkable objects on the moon's surface, we will suppose that she is between three and four days old. Arming, then, our three-inch telescope with a power of 120, we proceed to direct it to her face; and a very remarkable spectacle it is which will present itself to the student making his maiden observational essay on our satellite. He will first be struck by the number of ring plains, of which we have briefly spoken in our introductory paper, between the circular bright western limb of the moon, and the "Terminator"; by which name, as we have previously explained, the boundary of light and darkness is known. The Sea of Conflicts (A in our map on p. 223), and part of the Sea of Fertility (X) will also strike his eye. Before proceeding, however, to scrutinise the various objects contained within the bright crescent of the moon, it will be interesting to shift her image in the field of view of the telescope. If this be done, it will be found that the whole of the moon is visible; the dark limb looking like a very ghost on the black background of the sky. Moreover, if the atmospheric conditions are favourable, a certain amount of detail will be readily seen upon this dark portion of the moon, a bright spot, Aristarchus (148 in our map), and a dark one, Grimaldi (272), being the most conspicuous objects. We may shortly say here, with reference to this phenomenon, that it is the effect of earth-shine. Five minutes' study of the diagram illustrating the changes of the moon which appears in every elementary work on astronomy that has ever been written, will show that when the moon is new to the earth, the earth is full to the moon. Moreover, we present a disc to our satellite more than thirteen times the size of that which she exhibits to us, and hence it will be seen that the amount of light we send her at the time of her inferior conjunction (or when she is "new") must be very considerable. Of course, as the moon waxes to us, we wane to her, so that it is only during the first and last few days of every lunation that this earth-shine renders the dark side of the moon visible. Having satisfied ourselves as to its visibility, we will return to the illuminated crescent. Now, the craters and plains visible at the time of which we are speaking all present, more or less, an elliptical outline, the ellipticity becoming more and more marked as we approach the bright limb. If the student will regard a terrestrial globe from a little distance, he will at once understand that this is an effect of perspective. In fact, while the Sea of Conflicts (A) seems to have its major axis North and South, it in reality lies from East to West; this great, dark plain, measuring only 281 miles from North to South and 355 miles from East to West! We have called it a plain, but a little attention will show undulating ridges on parts of its surface. Its greenish grey tint will be noted, too. To the East of this "sea," Picard (4) will be seen. To the West of this is a white spot, which is a rather mysterious object, having been seen to present the most varying appearances. North-east of Condorcet (5) is the Promontorium Agarum, a kind of peninsula projecting into the Mare. This is a striking object when the moon is nearly sixteen days old. Cleomedes (12) is a fine formation, about seventy-eight miles in diameter. It has a trifid mountain in its interior. On its eastern wall is situated a very deep crater plain, Tralles (13 in the map). There is a central mountain on the floor of this, too. Endymion (27) is a circular plain (elliptical as it appears in the telescope). Its western wall rises in places to a height of upwards of 15,000 feet. Directing our instrument now towards the

Petavius. Moon's Age, 3·24 days.

southern half of the lunar crescent, we arrive at Langrenus (338) and Vendelinus (339), the former a splendid object, with a bright central hill. And now we come to that grand object, Petavius, which, as illustrating several typical lunar features, we have here drawn.

As seen in a three-inch telescope with a power of 120, the moon's age being 3·24 days, it will be noted how the wall is divided by narrow valleys. The mountain in the convex

interior is nearly 5,600 feet high; and from this a straight dark line, or "rill," will be seen to extend in a south-easterly direction to the wall. These rills, as they have been called, are very numerous on the moon; but few are so conspicuous as the one of which we are speaking. They appear to be exceedingly deep ravines, clefts, or cracks; but they are, undoubtedly, the most inexplicable of all lunar objects. Sometimes they pass through wall and plain indifferently; at others, they seem to stop short at an object, but to reappear on the other side of it. Moreover, they occasionally intersect. We shall have more to say of them as we proceed. Before concluding to-night's work, the attention of the young observer may be directed to one or two points of the Leibnitz Mountains (259), just coming into sunlight, and shining like stars close to the southern cusp of the moon.

In rebuilding the Pittsburgh and Western Railway as a standard-gauge road an extensive change was made at the Summit tunnel. The *Railroad Gazette* says:—"Its bed was lowered 9 ft. without stopping a train. The work was accomplished by the excavation of the bed of the tunnel while the track was kept up by trestle work. A row of blasts would be fixed ready for firing, and as soon as a train had passed through they would be touched off and the *débris* cleared up before the next train arrived. The track for the broad gauge was laid 9 ft. below the narrow gauge, and when all was ready cars were run in on the lower tracks and the trestle for the narrow gauge knocked down and dragged out." A similar operation was carried out some years ago with the tunnel near Blackburn, when Pulman cars first began to run in this country.

M. G. Tissandier has described to the Paris Academy of Science his new electrical motor for balloons. It consists of a screw propeller with two helicoidal blades nearly 10 ft. in diameter, a Siemens dynamo-electrical machine of new design, and a light bichromate of potash battery. It is intended to propel an elongated balloon of about 1,000 cubic yards capacity. The frame of the screw propeller weighs 15½ lb., is stretched with silk varnished with india-rubber lacquer, and kept taut by steel wire stretchers. The dynamo-electric machine has four electro magnets in the circuit, and frame parts are of cast steel, so as to bring the weight down to 121 lb. It drives the screw by gear, which reduces the speed in the proportion of 10 to 1; thus, if the coil makes 1,200 revolutions a minute, the screw makes 120. It gives out 220 foot-pounds per second with a useful effect of 55 per cent. The bichromate battery gives a better yield than accumulators of the same weight. It consists of an element divided into four series and arranged in tension. The element consists of an ebonite cell holding four litres—or 0·88 gallon—and containing ten plates of zinc and eleven cakes of retort carbon, arranged alternately. The immersed surface of the zinc is one-third that of the carbons. This battery, charged with a highly-concentrated and very acid solution, is constant for two hours. The liquid becomes heated as it is impoverished, and the duration of activity may be prolonged by the addition of chromic acid.

Errata.—"English Seaside Health Resorts" (Knowledge, No. 78).—Page 247, third line from the bottom, read instead of 20° −20°. Second line from the bottom, instead of 40° and 10°, read −40° and −10°. Page 248, line 26 from the top, read "barometer follows," instead of "barometer falling." Line 11 from the bottom, instead of "Tallusells," read "Tattersall's."

Reviews.

PRACTICAL GEOMETRY.*

Proficiency in practical geometry may be obtained without much (or, indeed, any) knowledge of mathematics, properly so-called; and, *vice versa*, many excellent mathematicians are very unskilful in practical geometry. We have sometimes thought that the two subjects might be brought into closer connection, in a treatise presenting mathematical truths and reasoning, in company with constructions depending thereon. In this way, we believe, practical geometry and mathematical geometry would both be made much more interesting and instructive. But, hitherto they have been kept very carefully apart. The present work is on the old lines. The constructions are given, and are meant to be learned, not proved, or even inquired into. Constructions which are only approximately correct are not distinguished from those which are geometrically exact. Trial methods are mixed up with strict constructional rules. The student is, in fine, kept closely to practical rules, and though encouraged in the preface to read Euclid, is not very likely either to do so or to have his progress in practical geometry much advanced by such reading. Albeit, as a work on practical geometry, this little treatise is as good as most, and better than many, works on the same lines.

The student of geometry would find it useful to take the propositions of this volume and prove them mathematically in the order in which they stand, showing in the case of those which are not exact the degree of approximation here attained. To do this thoroughly, however, will require more than a knowledge of Euclidean Geometry. The property on which Problem III., Part IV., is based, is a singular instance of close approximation obtained by a simple construction for all regular polygons from the pentagon to the dodecagon. It may be thus indicated as a formula:—

Let a be the side of a polygon of n sides, n being not less than 5 nor greater than 12. Then, if r is the radius of circle circumscribing the polygon, and we put

$$\frac{1}{36}(n-6)\pi = a$$

$$r^2 = a^2(1 + 2\sqrt{3}\sin a + 4\sin^2 a).$$

A Melbourne correspondent writes to the *Mining Journal* that already two gold mines are lighted by electricity, and that others are introducing the electric light.

The Academy of Painting and Sculpture at Berlin has been lighted by 200 Edison lamps. The dynamo is driven by a Ruston-Proctor engine of 16-horse power.

The Telephone in Boston.—An increase of 27,210 subscribers to the telephone in Boston is reported during the past year.

At a recent meeting of the Glasgow Town Council it was stated that the Bazaar Committee "had twice visited the eighteen electric clocks in the City, and on each occasion had found them all correct. The nineteen turret clocks under the charge of the Committee had also been visited, and ten were found correct, eight being slightly wrong and one standing."

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* "The Art Student's Second Grade Practical Geometry." By John Lowres. Revised to date and partly written by George Brown, of the Blackheath School of Art. (London: Moffat & Paige.)

"Let Knowledge grow from more to more."—ALFRED TENNYSON.

Letters to the Editor.

Only a small proportion of Letters received can possibly be inserted. Correspondents must not be offended, therefore, should their letters not appear.

All Editorial communications should be addressed to the EDITOR OF KNOWLEDGE; *all Business communications to the* PUBLISHERS, *at the Office, 74, Great Queen-street, W.C.* IF THIS IS NOT ATTENDED TO, DELAYS ARISE FOR WHICH THE EDITOR IS NOT RESPONSIBLE.

All Remittances, Cheques, and Post Office Orders should be made payable to MESSRS. WYMAN & SONS.

The Editor is not responsible for the opinions of correspondents.

NO COMMUNICATIONS ARE ANSWERED BY POST, EVEN THOUGH STAMPED AND DIRECTED ENVELOPE BE ENCLOSED.

[Many correspondents of KNOWLEDGE have, from the beginning of its career, indicated a wish that we should adopt something like the chatty style which (in response to that frequently-expressed wish) we have actually employed in our Gossip columns. A little space has been taken up in that way, which other correspondents grudge. Like the alderman who regarded the margin round his "proof before letters" as so much space wasted, these matter-of-fact souls count all which is not to be called "knowledge simply worded and exactly described" as waste or worse. Though few and ill-mannered, they mar the tone of our converse with our readers. If a host who had invited friends of scientific tastes to meet him, should, in his desire to entertain them, chat familiarly about other than strictly scientific subjects—for which, nevertheless, he left ample scope—and but a single guest, being rude of bearing, should object, he would yield to that one guest, though the rest should be more pleasantly disposed. For who cares to be familiar with his friends when even but one of the gloomily grumbling sort is present? For this reason we must ask the many kindly friends who have expressed pleasant approval of our Gossip to forgive us if we no longer accede to their wishes in regard to it. The dull souls who count every Gossip paragraph as so much stolen from them (but they never consider how generously they are dealt with in original matter, of which they get thrice as much here as in a magazine of thrice our cost), shall have their way. There will in future be no Gossip. We beg that they will *not* be at the pains to express their approval; and we should be rather glad if the much more numerous readers of the kindlier sort would let the matter pass without comment by letter, as our correspondence is falling dismally into arrears.]

COMETS' TAILS.

[802]—Mr. Ranyard is doubtless right in his observation that the discharge of gas from each stone of a meteoric swarm is greatest from the side turned towards the sun; but I do not think that the actual direction of motion in the case of each gaseous molecule, at the instant at which it becomes an independent projectile launched into space, can be much affected by this. The gas is not in a gaseous form while in the stone, but it takes this form at the instant of departure, and retains it until its volume is so far expanded that the molecules part company. While the gaseous form is retained the molecules are necessarily moving in equal numbers in all directions, by reason of their mutual encounters, whatever the initial direction of the impulse which shook them from their occluded state may have been; and, as any portion of the gas must expand to several million times the volume it occupied while in the stone before its molecules become independent of each other, the greater number of the molecules must at this time be quite independent of the stone.

The quantity of matter in a comet's tail must be very small, whatever his origin; but we can scarcely know what density is necessary to make a vast extent of gaseous matter, or of separated molecules, visible. Every molecule probably reflects a portion of the light falling on it, and though the effect upon our eyes may be insensible, and the result, therefore, utter blackness when the volume is a few cubic feet, it may be otherwise when we look through millions of cubic miles. I think, however, with Mr. Ranyard, that the presence of particles of the nature of smoke or dust may be inferred, and it seems probable that occluded gases when escaping would carry with them in molecular combination, and would afterwards precipitate minute portions of the materials from which they escape. ALBERT J. MOTT.

TIDE AND WEATHER.

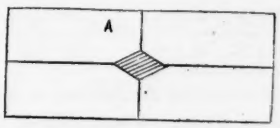
[803]—From observations made in London, and more especially in a coasting district, I can confidently assert that the state of the weather is always affected by high and low water, and that a change to a greater or less degree (sometimes almost inappreciable) takes place at, or a short period before, the turn of the tide.

ROBERT CONNELL, M.D.

THE GREAT PYRAMID.

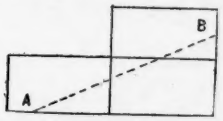
[804]—Pray allow me to thank you for your most interesting book on the Great Pyramid, and excuse my troubling you with a speculative guess respecting the so-called *ventilators*.

1. They can hardly have been solely for purposes of ventilation; for, if so, an immense amount of careful work might have been spared by making them perpendicular, as then it would only have been necessary to cut off the corners of the blocks of stone, and to build them up so that the cut corners should coincide in the successive layers, thus—



Horizontal Section.—Ventilator at A.

Instead of this, the tubes go in a slanting direction through the blocks, and must have been both difficult to cut and especially bad to join in the consecutive blocks.



Vertical Section.—Ventilator, A B.

2. From this I argue that they had some special—probably astronomical—use, and my guess is that the *northern tube* was to keep the orientation of the Pyramid correct in the upper layers; and that the *southern tube* was intended to observe the elevation of the sun when on the meridian at the winter solstice.

3. Perhaps you may be able to say if the northern ventilating tube points to the north in such a way as to preserve the orientation.

4. The southern ventilating tube was, I imagine, intended to solve this problem—Is the inclination of the earth's axis to the plane of the eclipse a constant quantity, or (as the problem would present itself to the ancient astronomers) are the maximum and minimum angular elevations of the sun at noon above the horizon (on longest and shortest days respectively) constant quantities, or are they slowly changing?

To resolve this problem, at first they may have accurately measured the shadow cast by the sun at noon on shortest day in successive years. This method, however, would soon be seen not to be sufficiently accurate to detect any change. A tube, down which the sun would shine only on the one day of the year, and which could be maintained in its exact position for three or four thousand years, would be a sufficient test; for (1,) if the axis of the earth became more nearly perpendicular, the sun would no longer

shine down the tube; and (2), if it became less perpendicular, instead of shining down the tube on Dec. 21, it would do so on two days, one before and the other after the winter solstice.

5. The idea of a chamber dark all the year, except on the one day when the sun is in an exceptional position, is thoroughly Egyptian; *e.g.*, in one of the rock temples of the sun its rays only reach the inner sanctuary at sunrise on the longest day.

6. If this guess as to use of tube F. G. is correct, it would account—

(1) For the accurate orientation of Pyramid, without which the tube could not be constructed.

(2) For one use of the grand (transit) gallery, which would be needed for observations as to the exact elevation of noonday sun at winter solstice.

(3) For the Pyramid being closed on completion. The secret of the entrance and the tube being kept by tradition among the priestly caste, so that at the end of, say 500 and 1,000 years, by which time the change (if any) could be observed, it could be re-entered.

7. Possibly you may have measurements of sufficient accuracy to decide if the direction of the tube is such as to make this supposed use possible, or, if it has not been observed, by mentioning the matter in KNOWLEDGE, some future observer could settle the point.

A. M. DEANE.

P.S.—I was amused to see you printed my symmetrical solution of the twenty-one girls' problem in preference to the author's, but I should like to have seen the latter.

TWENTY-ONE SCHOOL-GIRL PUZZLE.

[805]—Let the girls be designated by numbers, 1 to 21, and divided into sets, each of three consecutive numbers, the sets numbered 1 to 7. The numbers are considered as arranged in a circle, so that we may count forward from 7 to 1, and say that set 3 is the 3rd set from set 7.

Make two squares, one of the 1st, 2nd, and 4th sets, the other of the 3rd, 5th, and 6th, as follows:—

1	2	3
4	5	6
10	11	12

7	8	9
14	15	13
18	16	17

(Observe the order of writing the numbers in the second square.)

These squares are divided vertically into six groups of three, which, with the seventh set—19, 20, 21—as a seventh group, makes an arrangement of girls for the first day. Make the second day's arrangement from the first, by adding 3 to each number and subtracting 21, when the addition makes more than 21; the third day's arrangement from the second's in like manner; and so on until you have arrangements for seven days. Then take the sets composing one of the above squares, and make a third square of them in this way:—

1	2	3
6	4	5
11	12	10

The three columns of this square furnish one group for the arrangement for each of the three remaining days, and the other groups are formed from them by successive additions of 3, &c., just as the arrangements for the days from the second to the seventh were formed each from the arrangement of the preceding day.

Proof.—By the successive additions of 3, the three squares given above may be considered as extended into three sets of squares, and in each set of squares each line is occupied by all the sets of three consecutive numbers successively. In every square two consecutive sets are combined, two sets whose numbers differ by 1 and two whose numbers differ by 2, so that in each set of squares each set of numbers is combined with every other set. But, when the same two sets of numbers are combined in different squares, they are combined in different ways. For instance, the first and second sets are combined in the first set of squares—1 with 4, 2 with 5, 3 with 6; in the second set—1 with 5, 2 with 6, 3 with 4; and in the third set—1 with 6, 2 with 4, 3 with 5; so we see that not only is each set combined with all the other sets, but every number of every set is combined in a group of three with every number of every other set, and, as on each of the first seven days one set forms a group by itself, every one of the 21 numbers is combined with each of the other numbers.

ALGERNON BRAY.

"31" GAME.

[806]—I think you might, perhaps, be interested by a game or puzzle of the above name, which has lately made its appearance in New York, and of which the following sketch may give you an idea:—

1	1	1	1	
2	2	2	2	
3	3	3	3	
4	4	4	4	
5	5	5	5	
6	6	6	6	

The sketch represents a box divided by longitudinal partitions into six parts, and containing twenty-four numbered blocks. The blocks being first placed on one side of the box, two players alternately move one block at a time to the other side, keeping count of the sum of the numbers on the blocks moved, as if they were playing cribbage. The player who makes 31, or who comes so near 31 that the other cannot play without making more than 31, wins the game.

The inventor of the game seems to have intended that the blocks should always be placed in the box in the above order. Even with this restriction, the game presents a tolerable problem, though it has not much variety. But if the blocks might be placed in any way you pleased, four in each row, there would be a great variety of problems, the number of essentially different arrangements being, I believe, 4,509,264,634,875. The problems would often be exceedingly complicated, and there would be room for a good deal of skill in play.

The box of blocks is by no means necessary in order to play the game. You can readily see how it could be played with cards, and, from the above regular arrangement, with a pencil and paper.

ALGERNON BRAY.

THE SQUIRREL PUZZLE.

[807]—As a reader of KNOWLEDGE, I hope you will excuse what I am about to put before you, but I cannot arrive at the same conclusions as you in regard to the squirrel and the man going round him.

Supposing the squirrel that sits on the post holds a piece of string in his mouth and the man has hold of the other end and walks round the post, the squirrel turning at the same time; if your conclusions are correct, the man must go around the piece of string the squirrel holds in his mouth, and, consequently, round the piece the man holds, or round himself [he does rotate—R. P.]; otherwise, there must be a point in the string where the man leaves off going round it. I cannot see how the man goes round the string or squirrel in the same sense that he has gone round the post.

You might as well say that we go round the earth every time the earth turns on her axis. [Do we not?—R. P.]

Perhaps, after all, we only disagree as to what is going round an object. I consider that in going round an object we see during the revolution every side of it, or that every side is presented to us in its turn.

W. SMITH.

[In what way does the expression going round an object imply seeing every side of it. Suppose the man shut his eyes, would that make any difference? Or, suppose the man stood still and the squirrel turned round, so as to show him every side—would the stationary man have gone round the squirrel? In the original supposed case of the squirrel turning, he simply rotated; the string shares the motion of revolution. We cannot deal with that case except by using the more rigid definition of revolution.—R. P.]

MUSICAL QUESTION.

[808]—How is it that the same chord, if struck in two different keys (say C Major and C-sharp Major), has a different sound—irrespective of pitch—when a pianoforte is tuned to equal temperament?

I have heard that there is a solution, but I have never come across it, and many musical friends are unable to enlighten me on the subject. I therefore appeal to you, Mr. Editor.

WALTER JONES.

[The question is left to musical correspondents. It has always seemed to me that there is something akin in the fact mentioned by Mr. Jones to the way in which a luminous surface presents a dif-

ferent appearance according to its surroundings; or, more coarsely, to the way in which tepid water appears hot or cold to a hand placed in it after being in cold or hot water respectively.—R. P.]

THE DIVIDED SKIRT.

[809]—I have read the letter on the new skirt by "A Lady," in KNOWLEDGE, April 13, and I think the description may prejudice many against this valuable garment.

The only similarity to gentlemen's trousers is the division. Each leg is one yard in circumference, and the whole is loose and comfortable. The appearance of mine is so like a petticoat that in raising the dress the difference is imperceptible.

I have given a pattern, in three sizes, with instructions, to Miss M. Knight, High-street, Maldon, Essex; and she is prepared to supply them to any one on receipt of a Postal Order for One Shilling.

A MEMBER OF THE L. S. A.

[The author of the article referred to informs us that many ladies prefer the divided skirt as she described it, and even less "full" (whatever that may mean); but that, even as described by her, the appearance is like a petticoat when the dress is raised, as in stepping into a carriage. Quite a number of correspondents, by the way, seem to imagine that the skirt of the *dress* is divided. One even asks if we could not publish a photograph of "A Lady" to show what the divided skirt is like, which, of course, would be quite out of the question, even though it would show the divided skirt. The mistake about the skirt probably arises from the pictures which have appeared in *Punch* and other comic papers, showing a divided dress. The divided skirt is entirely concealed by the skirt of the dress, which is not divided at all. I am requested to note that for tricycling the divided skirt is better without the plaits, which are apt to catch as the feet pass each other.—R. P.]

INTERPLANETARY ÆTHER.

[810]—With reference to G. M.'s letter on the rotation of planets (No. 776, p. 210) and your footnote thereon, will not the hypothetical ether, if such a substance there be, have some effect in acting as a "break" on the rotation of planets, and likewise as a resisting force on their circuits round the sun? I suppose it is now pretty well established that some such substance must pervade, space acting as a link of intercommunication between the widely-scattered parts of the material universe. It is evident that there must be some medium of communication, as the waves of light cannot be propagated through a void, but must have some material pathway. Such a substance must also offer a resisting medium to the passage of the heavenly bodies through space, and, given sufficient time, must ultimately bring them to rest, unless their initial force is renewed from without. Granting this resisting medium, it is clear that the gravitating force of the sun will eventually overcome the centrifugal tendency of the planets, and draw them one after another into it. I will be glad to hear what science has to say on this point, and whether any evidence of such a resisting medium has been observed.

W. M.

[We infer the extreme, the practically infinite, tenuity of interplanetary matter, from the fact that neither rotation nor revolution is appreciably affected by it.—R. P.]

ANIMAL INSTINCTS.—A WRANGLER'S PUZZLE.

[811]—George J. Romanes, Esq., in a lecture delivered in the Hulme Town-hall, Manchester, March 1879, said, in referring to animal instincts, that there were satisfactory reasons for concluding that most animal instincts were the outcome of a natural growth, and that the few outstanding cases which were not capable of explanation (at that time) in this way ought to be considered as objects for further scientific inquiry, and not to be set down as supernatural, and, therefore, beyond the scope of such inquiry. The instincts not susceptible of explanation in this way were enumerated by him to be (1) the migratory instinct, (2) the so-called "homing" instinct, and (3) the instinct manifested by certain wasp-like insects. "These insects," he said, "lay up a store of spiders as food for their larvæ when the latter leave the egg. To do this they sting the spiders in a certain spot of the body where there is a large nerve-centre, the effect being that the spider is not killed outright, but merely paralysed, and so does not decompose during its imprisonment, and while the eggs of the wasp are in the process of hatching."

Perhaps some of your biological readers may be able to say whether further "scientific inquiry" has been made, and with what results.

I have seen no answers to "A Wrangler's" questions (No. 70, p. 138). In reference to (1), if the man threw some object (say his cap) away from his body, would not the reaction dislodge him? I could not answer for him escaping without bodily injury.

H. ASKEW.

[That would do; but if he had no such object to throw, blowing would do: he would slide off, and have to take his chance as to the sequent fall.—R. P.]

A DISCOUNT DODGE.

[812]—The multiplication "dodge," given by Mr. Green (759, p. 168), brought to my memory a discount "dodge," of which a friend of mine was wont to make use, and which I never saw used before, nor referred to in any arithmetic. I dare say my friend found it in some book, but I never questioned him on this point, and cannot do so now, seeing that he, poor fellow, gave over figuring on this earth some six or seven months ago. To find out the discount on any sum at the rate of $2\frac{1}{2}$ per cent. or 5 per cent. is easy enough, without the aid either of figures or an interest table; but, to find out the discount on a given sum, at such rates as $3\frac{1}{2}$ per cent., $3\frac{3}{4}$ per cent., $4\frac{1}{4}$ per cent., &c., is not so easy. My friend's plan was to multiply the principal sum by double the rate of discount, the product, after cutting off the right-hand figures, showing the amount of the discount in shillings—thus, supposing an invoice amounting to £132. 15s. had to be subjected to a discount of $3\frac{1}{2}$ per cent., the operation of calculating the same, according to the long way and the short way, would be as shown below:—

Long Way.	132	15	0			
				$3\frac{1}{2}$		
	398	5	0			
	66	7	6			
	4,64	12	6			
		20				
	12,92					
		12				
					£	s. d.
	11,04			=	4	12 11
Short Way.	132	15	0			
				7		
	92,9	5	0			
		12				
					£	s. d.
	11,3			=	4	12 11

G. M.

LETTERS RECEIVED.

MORE LIGHT. All right.—J. G. JOHNSON. Hope to lecture there and elsewhere soon.—NO NAME, BUT NO MALICE. No sense and no manners.—G. F. The phenomenon was a paraselene—not very common, but well known.—G. F. M. Thanks.—*a* CENTAURI. Impossible to answer you here.—NATURALIST. An old joke, but good.—ATTENTIVE READER OF "KNOWLEDGE." Questions forwarded.—J. MUNRO. Quite natural. But then you see those paragraphs, &c., which *you* do not care for were written in response to the wishes of others who take a different view. I do *not* tell you to cease to read KNOWLEDGE, but can you not leave out those paragraphs here and there which you do not care for, remembering that tastes differ?—JOHN GREENFIELD. How many times your annual subscription would pay, do you suppose, for such a letter as yours? Try this little sum. Are you, by any chance, one of "the great men," *all* of whom you say "I have offended, and consequently no one will write for me"? Now, before you retire in dudgeon and discontent (but very much to my content), learn that I am not aware of having offended a single "great man." Nine-tenths of those whom I have invited to write here have done so, and are likely to continue. You must not think that because I declined to give admission to certain wild theories of your own, I have offended all the rest of "the great men." As for "resigning," to whom *should* I resign? To the proprietor of KNOWLEDGE? Very well. The Editor of KNOWLEDGE hereby offers his resignation to the proprietor; and the proprietor of KNOWLEDGE hereby declines to accept the Editor's resignation.—HENRY LUPTON. Consider that I raise my hat to you in token of adieu, and pass on. (Little space wasted here, any way.)—C. T. HIGHGATE. Omittance is no quittance.—H. C. SWAN. Doubt if Dr. Wilson would gravely reply to any advocate of the old phrenology.—C. P. L. B. Do not know of any work on the miocene formation, and especially on the Savalik Hills of India; but perhaps some correspondent of KNOWLEDGE may be able to tell us of one.

XUM

Our Mathematical Column.

IN our last, we found the area we first set out to find—viz., A P K N (in Fig. 2)—by an application of the integral calculus; though we should have failed if we had not known that

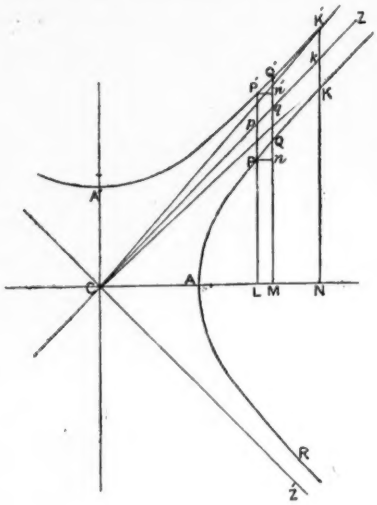


Fig. 2.

$\int \frac{dx}{x} = \log x$, and therefore if we had not first had the particular function called a logarithm invented for us, and its qualities, value, and so forth, ascertained.

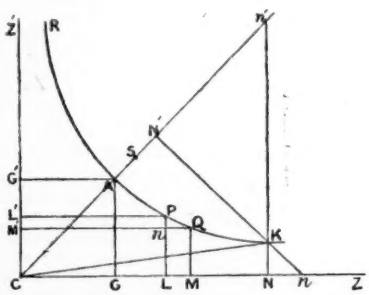


Fig. 3.

But we want also, now, to learn what is the integral of $\sqrt{x^2-a^2}\,dx$. We can form a pretty shrewd guess from the value we have already obtained for the area A P K N′ (Fig. 3). If we write x for x_1 in that expression, and differentiate with respect to x, we find that that expression *is* the integral we want. However, we prefer to work it out properly. And noting its resemblance in form to the integral of $\sqrt{a^2-x^2}$ we are led naturally to deal with it in the same way. It would, in fact, be obviously the correct thing at this stage to see if the short method given for finding that integral may not be applied directly to this one. Let us see. Integrating by parts

$$\int \sqrt{x^2-a^2}\,dx = x\sqrt{x^2-a^2} - \int \frac{x^2\,dx}{\sqrt{x^2-a^2}}$$

$$\text{Also} \int \sqrt{x^2-a^2}\,dx = \int \frac{(x^2-a^2)\,dx}{\sqrt{x^2-a^2}} = \int \frac{x^2\,dx}{\sqrt{x^2-a^2}} - \int \frac{a^2\,dx}{\sqrt{x^2-a^2}}$$

$$\therefore \text{adding, } 2\int \sqrt{x^2-a^2}\,dx = x\sqrt{x^2-a^2} - \int \frac{a^2\,dx}{\sqrt{x^2-a^2}} \quad (1)$$

Here we find ourselves stopped for want of knowledge as to the integral of $\frac{dx}{\sqrt{x^2-a^2}}$. In the other case we had, instead, $\frac{dx}{\sqrt{a^2-x^2}}$, and we knew the integral of this to be $\sin^{-1}\left(\frac{x}{a}\right)$; but we have not yet determined the integral of $\frac{dx}{\sqrt{x^2-a^2}}$. How shall we set to work to find it? Manifestly our proper course is to take advantage of what we have already learned, viz., that the part of the integral we yet have to find involves $x+\sqrt{x^2-a^2}$. This suggests our adopting the method of substitution and putting $x+\sqrt{x^2-a^2}=z$,—that is $\sqrt{x^2-a^2}=z-x$. Then $x^2-a^2=z^2-2xz+x^2$; or $2xz-z^2=a^2$.

Whence

$$2x+2z\frac{dx}{dz}-2z=0$$

$$\text{or} \quad \frac{dx}{dz}=\frac{z-x}{z}$$

Hence we have

$$\int \frac{dx}{\sqrt{x^2-a^2}} = \int \frac{1}{z-x}\cdot\frac{dx}{dz}\cdot dz = \int \frac{dz}{z}$$

$$= \log z = \log\left(x+\sqrt{x^2-a^2}\right)$$

and thus we are able to complete the desired integration (1), and obtain from (1)

$$\int \sqrt{x^2-a^2}\,dx = \frac{x\sqrt{x^2-a^2}}{2} - \frac{a^2}{2}\log\left(x+\sqrt{x^2-a^2}\right)$$

It will be found that $\frac{1}{\sqrt{x^2+a^2}}$ and $\sqrt{x^2+a^2}$ may be similarly integrated.

(To be continued.)

AN EQUATION.

H. E. P. C. gives the following simultaneous for solution:—

$$\frac{1}{x}+\frac{1}{y}=a \qquad x^2-y^2=b$$

find x and y in terms of a and b. It was given him by the late Mr. Bidder.

[If we consider the conics represented by these two equations, we shall see that they cannot possibly be made to give a quadratic equation in x or y.—R. P.]

Our Whist Column.

BY "FIVE OF CLUBS."

"DO YOU PLAY WHIST?"

IT is amusing to compare the answers given to this question with the results observed when the game has fairly begun. "Do you play Whist?" "Certainly! I have played Whist for years, and I flatter myself I know something about it by this time." The game begins, and you find the gentleman who has answered so confidently knows simply nothing about the game beyond the rules for following suit, counting honours, and so forth, which a beginner is taught in the first ten minutes of his acquaintance with Whist. He not only has no idea of Whist as a game in which each player has a partner, but he does not even know how to play his own hand. He leads out every winning card, weakens his trumps recklessly in ruffing, when—if he knew anything of the game—he would see that by leading trumps, or at any rate reserving his force in trumps, he might bring in a long suit. He, perhaps, has just so much thought of his partner as to return whatever suit his partner may have led. Very likely he does this when it is his clear duty to show his own suit, or when it should be obvious from the play that his partner has led from weakness. Or, again, he may so far think of his partner as to force him whenever he gets the chance, though as often as not forcing means disarming.

Another tells you he plays Whist well who has indeed an idea of the general principles on which sound play should depend, but knows none of the details essential to the application of these principles in a practical way. He knows, for instance, that when you lead trumps you generally want trumps exhausted; but he imagines he does enough in helping you to this end when he returns your trump lead. He is perplexed and aggrieved when you tell him that by returning the wrong card he has utterly foiled all your plans. Thus, holding Ace, Queen, nine, and two of trumps, you lead, let us say, the two, on which fell seven, King, and five; he returns the

three, on which fall the six, your Queen, and eight on your left. Now, so soon as he played the three, you were justified in assuming (if he knows how to play the game) that he holds the four and another, for neither of the opponents holds the four, and you have it not yourself, therefore he must have the card; and having both the four and the three, he should return the four, if he holds no other: so that, as he returns the three, you assume he holds another. You play the Ace, the ten falls on your left, your partner plays the four, and the fourth player discards from a plain suit. You believe all the trumps to be extracted from the enemy, and, moreover, that you and your partner are four by honours. Acting on this belief, you play out King-cards, which you would otherwise have retained; and then you bring in your partner's long suit, which had been already, we will suppose, established. But, to your disgust, you find that your opponent on the left still holds the Knave, with which he stops your long suit; brings in his, with which he finally forces out your long trump, and, having no card in your partner's suit, you are obliged to lead either from one of the adversaries' suits or from a suit in which they hold the King-card, so that they bring in their winning cards. *Then* perhaps you waste time trying to convince your partner that his playing the three before the four made all the difference, with no other result but to be rebuked by him for giving up the command in your adversaries' suits, a mistake which, but for your explanation, he would have known nothing about, and which would not have been a mistake at all if his play had really meant what to every understanding Whist-player it implied. Of course, you mistook in assuming that because he said he could play Whist he knew something about the elementary rules of the game.

Players who make such blunders as these are apt to argue, when, after a time, it becomes clear to them how badly they play, that as they cannot get to remember what cards have been played, and by whom, to notice the signal, and so forth, it is not worth their while to learn such minutiæ as the return of the proper card from two or from three. But that is just where they are mistaken. These points should not be regarded as minutiæ, but as the A B C of the game. It may be difficult to attend closely to the fall of the cards, to draw the right inferences, and to retain to the end what has thus been learned, but it is not at all difficult to fall into the constant habit of returning the highest card of two, the lowest of three, left in the hand after the first round of a suit. It is noteworthy, too, how care in such matters helps to aid the memory, and keeps alive the attention. After learning to return the right card, you very soon find yourself noticing the card returned by your partner, or by the adversaries to each other. Next you find that when thus informed as to the number of cards of different suits in different hands, you presently begin to recognise where the individual cards of the suit must lie. The more you notice, the easier it is to retain what you notice in your recollection—precisely as Mr. Proctor, I do not doubt, finds it much easier to recollect new astronomical measures than most of us do, because, having already a number of such measures in his memory, new ones fit themselves in among the rest, so as to be more easily remembered.

(To be continued.)

Our Chess Column.

By Mephisto.

ANSWERS TO CORRESPONDENTS.

*** *Please address Chess Editor.*

C. Planck.—Problems received with thanks.

Francis J. Drake.—No general time limit can be fixed for solving problems. To solve slowly is better than not solving at all.

Charles Bowen.—Thanks for good wishes. Solutions incorrect. No. 84, If 1. Q to R4, B takes Q. 2. R takes P(ch), K to Kt4. 3. B to K8(ch), Kt to B3(ch)? No. 85, 1. R takes Kt (ch), K to R2. 2. Kt to Kt6, R to Q5, and again there is no mate.

C. G. S.—No. 85. If 1. Q to K7, Kt to B3(ch). 2. K takes P! and mate next move.

William H. Steer.—See reply to Charles Bowen.

D. Duggan.—Solution incorrect—see above reply. The games of the late tournament have not been published.

Correct solutions received.—Problem 84.—East Marden, G. Woodcock, Francis J. Drake, G. W. Thompson. No. 85.—G. Woodcock, John, R. J. P., M. T. Hooton, T. T. Dorrington.

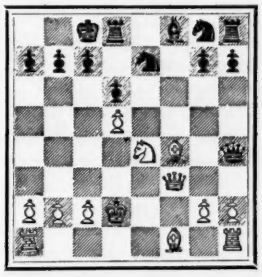
LONDON INTERNATIONAL CHESS TOURNAMENT.

THE tournament commenced on Thursday, the 26th ult., in a spacious and artistically decorated hall at the Criterion. All the players, and a goodly number of spectators, assembled there before twelve o'clock. Play commences at noon punctually, and is carried on up to 5 p.m., at which time an adjournment takes place, to be resumed from 7 p.m. until 11.45. The pairing for the first day was rather remarkable, as the two victors of Vienna, Steinitz and Winawer, were drawn to play together. The chief interest of the day was centred in their game.

Steinitz opened with his favourite, the Vienna Opening—viz., 1. P to K4, P to K4. 2. Kt to QB3, Kt to QB3. 3. P to B4. Winawer accepted the Gambit by P takes P, whereupon Steinitz, very much against the expectations of many, played his own favourite move of 4. P to Q4. The game proceeded with Q to R5(ch). 5. K to K2, P to Q3. This is a weak rejoinder. (With P to Q4 instead, the game could be brought to a position in which Mackenzie drew.) Then followed 6. Kt to B3, B to Kt5. 7. B takes P, Castles (the usual move is B takes Kt ch). 8. K to K3, B takes Kt. 9. Q takes B, P to B4. 10. P to Q5, QKt to K2. 11. K to Q2, P takes P. 12. Kt takes P, arriving at the following singular position:—

WINAWER.

BLACK.



WHITE.

STEINITZ.

It will be seen, after careful examination, that White threatens to win the Queen by B to Kt 5. P to KR3 is no defence, on account of P to KKt3. Also P to KKt3 would not help Black, as White can play as follows:—

12.	P to KKt3
13. P to KKt3	Q to R4
14. Q takes Q	P takes Q
15. Kt to Kt5	Kt to R3
16. Kt to K6	R to Ksq

17. Kt takes B, followed by B takes Kt, and wins.

Winawer played 12. Kt to B3. 13. Kt to Kt5, Q to R4. 14. Q takes Q, Kt takes Q. 15. Kt to B7, Kt takes B. 16. Kt takes QR, &c. Although being an exchange behind, Winawer made a gallant stand, and even obtained a good chance for a draw. This, however, he missed, and lost after 6½ hours' play.

Another very interesting game was fought between Mason and Mackenzie. It will be recollected that Mason came out third, with 23, at Vienna, while Mackenzie scored 22½. The opening was a Giuoco Piano, somewhat after the form first adopted by Blackburne in his match with Zukertort, and also very often played by Mason. 1. P to K4, P to K4. 2. Kt to KB3, Kt to QB3. 3. B to B4, B to B4. 4. P to Q3, P to Q3. 5. B to K3, B to Kt3. 6. P to B3, Kt to B3. 7. Kt to Q2, B to K3. 8. B to QKt5, Castles. 9. B takes Kt, P takes B. 10. B to Kt5, R to Ksq. 11. Kt to B sq, R to Kt sq. 12. Q to Q2, P to KR3. 13. B to R4, B to Kt5. 14. P to KR3, B to Q2? 15. B takes Kt, Q takes B. 16. Kt to Kt3, &c. Mason conducted this game with great strength and perseverance, and defeated his opponent in fifty-two moves.

Sellman adopted the French Defence against Blackburne. The game, after the exchange of Queens, stood pretty even, when Blackburne, on his twenty-ninth move, proposed a draw, which was accepted.

Rosenthal played the Scotch Gambit of 4. B to B4 against Bird. The latter scored an advantage in the opening, which gave him a

good game in the ending. Rosenthal, however, equalised matters, and, after forty-seven moves and six hours' play, the game was abandoned as a draw.

Tschigorin was opposed to Zukertort, playing the Ruy Lopez. The latter played in very fine style, and won after twenty-nine moves.

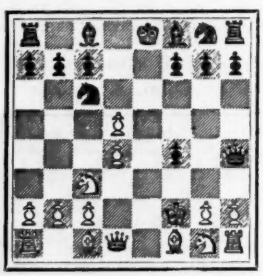
It was also remarkable that the two English amateurs, Skipworth and Mortimer, were drawn against each other. The former opened with 1. P to QB4, to which Mortimer made the unsatisfactory reply of P to K4, followed by P to KB4, the result being that Skipworth won after forty-seven moves.

Noa played the Ruy Lopez against English. The latter proved himself as strong and tenacious as ever, and initiated a fine combination on his twenty-fourth move, and won after thirty-two moves.

Friday, the 27th, Steinitz was opposed to English. The former opened with his favourite, the Steinitz Gambit, and the game created no little surprise and excitement amongst spectators. 1. P to K4, P to K4. 2. Kt to QB3, Kt to QB3. 3. P to B4, P takes P. 4. P to Q4, Q to R5(ch). 5. K to K2, P to Q4 (best). 6. P takes P, Q to K2(ch). 7. K to B2, Q to R5(ch).

English.

Black.



White.

Steinitz.

The same position was arrived at by Steinitz in his match with Mackenzie, and was given up as a draw. Steinitz essayed to avoid the draw, and lost. The following continuation ensued :—8. P to KKt3, P takes P. 9. K to R2, B to K3 (very fine). 10. P takes Kt (weak), P takes P. 11. Q to B3, P takes Kt(ch). 12. K takes P, Q takes P(ch). 13. B to K3, Q to B3. 14. Q to K2, Kt to K2. 15. B to Kt2, P takes P. 16. Kt to K4, Q to Kt3. 17. P to B4, B to KKt5. 18. Q to KB2, Castles. Black remained with three pawns to the good, and after about a dozen more moves, Steinitz resigned, amidst intense excitement.

Of equal interest to the proceedings was the contest between Blackburne and Mackenzie, which lasted over the adjourned till late in the evening, it being the only game going. The ending was particularly interesting. After a hard struggle of sixty-four moves, the game resulted in a draw, although Mackenzie had somewhat the best in the ending. We give the game in full.

Mason played his Giuoco Piano against Skipworth, and won ; and Zukertort again won in fine and lively style against Mortimer. Bird played a peculiar form of the Giuoco Piano against Winawer. He obtained some advantage, but the game ultimately resulted in a draw, as did also the game of Rosenthal *v.* Sellman, and Noa *v.* Tschigoryn.

Draws do not count till after the third draw, when they count half. Saturday is merely intended for adjourned games, or players who have drawn during the week. Accordingly, on the 25th, those players that had drawn met again. Bird defended the Cicilian against Winawer. The latter conducted the opening in a novel but weak manner, and soon lost the advantage of the first move—viz., 1. P to K4, P to QB4. 2. Kt to QB3, P to K3. 3. Kt to KB3, Kt to QB3. 4. B to Kt 5 (?), Kt to Q5. 5. Castles, P to QR3. 6. B to K2, P to Q4. 7. Kt takes Kt, P takes Kt. 8 Kt to Kt sq (?), B to Q2. 9. B to B3, B to B3, &c. Bird won the game, playing in good style. Tschigorin beat Noa. The third draw to be played off was between Blackburne and Mackenzie. This again proved a very severe struggle, lasting 8½ hours, with the result that Mackenzie won.

In the minor Tournament, twenty-six players compete for honours. Of these, Messrs. Lambert and Gunsberg stand best, the former having played six games and the latter four games, winning them all.

SCORE UP TO TUESDAY NIGHT.

	Bird	Blackburne	English	Mackenzie	Mason	Mortimer	Noa	Rosenthal	Sellman	Skipworth	Steinitz	Tschigoryn	Winawer	Zukertort	Draws not counting	Total score
Bird	—											0	1		3	1
Blackburne		—		0						1					3	1
English			—				1				1				2	2
Mackenzie		1		—	0					1				0	1	2
Mason				1	—					1				0	1	2
Mortimer						—	0			0	0			0		0
Noa			0			1	—					0			2	1
Rosenthal								—	0						4	0
Sellman								1	—				0		3	1
Skipworth		0			0	1				—						1
Steinitz			0			1					—	0	1			2
Tschigorin	1						1				1	—		0	1	3
Winawer	0								1		0		—		2	1
Zukertort				1	1	1						1		—		4

Game played in the second round of the London International Chess Tournament, on April 27, 1883 :—

GIUOCO PIANO.

White. Blackburne.	Black. Mackenzie.	White. Blackburn.	Black. Mackenzie.
1. P to K4	P to K4	33. Q to Kt2	R to B2
2. KKt to B3	QKt to B	34. K to R2	R(R5) to KB5
3. B to B4	B to B4	35. R to KKt sq	P to KKt4
4. P to B3	Kt to B3	36. Q to K2	R(B2) to B4
5. P to Q3	P to Q3	37. K to Kt2	Q to B2
6. B to K3	B to Kt3	38. R to KB sq	Q to K3
7. QKt to Q2	B to K3	39. R to Kt4	K to B2
8. Q to K2	Q to K2	40. K to R2	P to B4
9. Castle KR	P to KR3	41. R takes R	R takes R
10. B to QKt5	Castles KR	42. R to K sq	R to KR5
11. P to KR3	B to Q2	43. Q to Kt2	Q to B4
12. Kt to B4	Kt to R2	44. Q to Kt3	R to KB5
13. B takes B	RP takes B	45. R to K3	K to B3
14. Kt to K3	B to K3	46. K to Kt2	P to B4
15. P to R3	P to B4	47. P to Kt4	P takes P
16. P takes P	B takes P	48. BP takes P	R to Q5
17. Kt takes B	R takes Kt	49. Q to B2!	R to R5
18. B takes Kt	P takes B	50. P to B4!!	R takes BP
19. Kt to Q4!	R to B5	51. Q to QB2	Q to K3
20. Kt takes P	Q to Q2	52. P to Kt5	P to Kt5
21. Kt to Kt4	Kt to Kt4!	53. P to KR4	P to Q5
22. P to B3	QR to KB sq	54. R to K4	Q to Q4
23. Kt to Q5	R to KR5!	55. P to R4	Q to Kt2
24. R to B2	Q to B2	56. K to Kt sq	R takes R
25. Kt to K3	Kt to K3	57. P takes R	K to K2
26. K to R2	Kt to B5	58. P to R5!!	K to Q3
27. Q to B sq	Kt takes RP!	59. P to R6	Q to QB2
28. P takes Kt	Q to B5(ch)	60. Q to QR2	Q to B8(ch)
29. K to Kt sq	Q takes Kt	61. K to Kt2	Q to KB5
30. R to K sq	Q to Kt4(ch)	62. Q to Q5(ch)	K to K2
31. R to Kt2	Q to R4	63. Q to Kt7(ch)	K to K sq
32. R to Kt3	P to Q4	64. Q to B8(ch)	K to K2

Drawn.
Duration 9 hours.

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